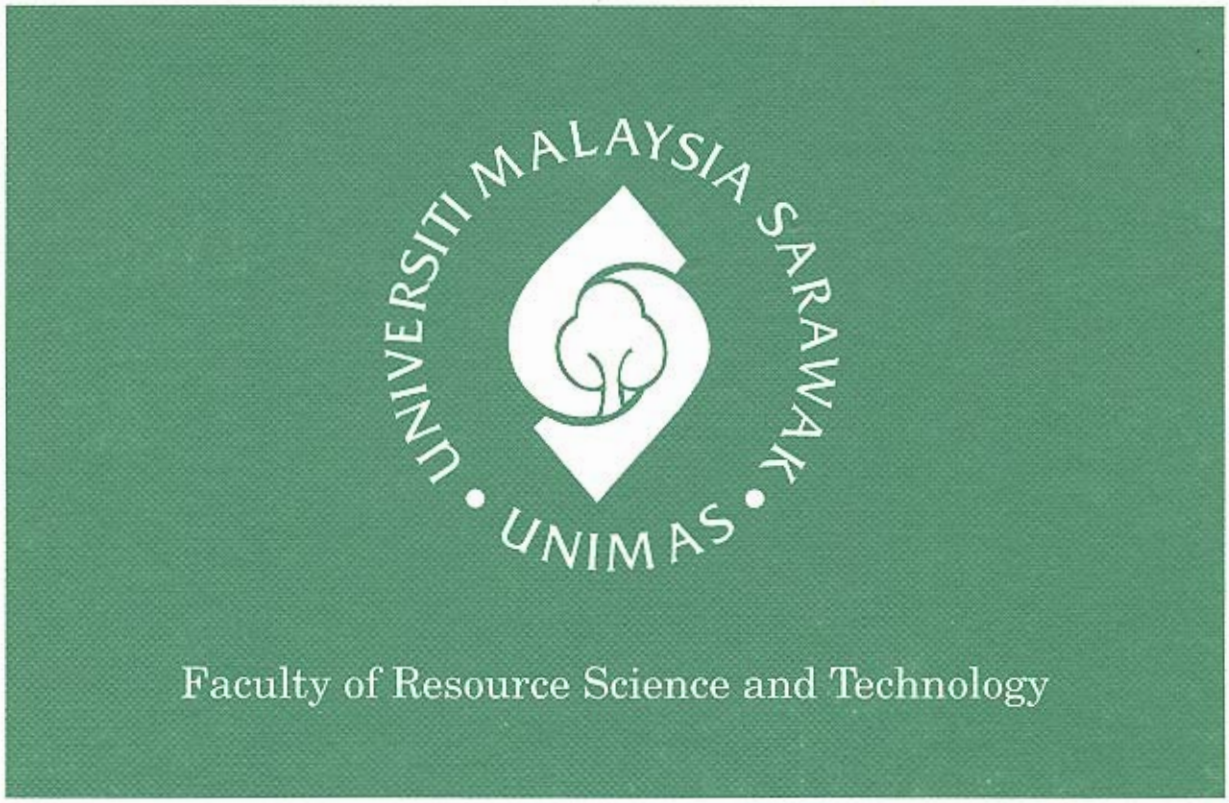

ECOLOGY AND POPULATION DYNAMICS OF MEIO-MACROBENTHOS IN BATANG SARIBAS

Kasi Visalatchy Krishnan

Bachelor of Science With Honours
(Aquatic Resource Science and Management)
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This project is submitted in partial fulfillment of
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ABSTRACT

A preliminary study of the ecology and population of meio-macrobenthos communities was carried out in Batang Saribas. This study is primarily aimed at description of the meio-macrobenthos community in Batang Saribas and its correlation with physico-chemical parameters. A few physico-chemical parameters and samples of meio-macrobenthos were taken. It's was found that the study area is tropical estuary water with similar feature of physico-chemical components as other rivers in Sarawak. The study area was muddy with high portion of organic matter. Eight taxa of meiobenthos and macrobenthos were recorded respectively. They are Amphipoda, Bivalvia, Cumacea, Foraminifera, Gastropoda, Harpacticoida, Insecta, Nematoda, Oligochaeta, Ostracoda, and Polychaeta. Polychaeta was dominant taxa here. Both meiobenthos and macrobenthos at this study area were not evenly distributed. Out of eleven meio-macrobenthos taxa that documented at sediment, only nine taxa were recorded consumed by the puffer fish at study area. Meio-macrobenthos was found as one of the important food source for puffer fish in Batang Saribas. The results obtained can be used as a baseline data for further conservation programme of puffer fish in the Batang Saribas area.

Key words: Ecology, population dynamic, meio-macrobenthos, Batang Saribas.

ABSTRAK

Kajian tentang ekologi dan populasi dinamik komuniti meio-makrobentos telah dijalankan di Batang Saribas. Kajian ini bertujuan mengkaji taburan komuniti meio-makrobentos dan hubungannya dengan fizikokimia parameter. Persampelan bagi fizikokimia parameter dan sedimen (untuk meoifauna dan makrofauna) telah diambil. Kawasan kajian didapati mempunyai ciri-ciri estuari seperti yang dicatatkan untuk sungai-sungai lain di Sarawak dalam kajian-kajian lepas. Kawasan ini juga berlumpur dan kaya dengan bahan organik. Lapan taxa meiobentos dan makrobentos dicatatkan masing-masing iaitu Amphipoda, Bivalvia, Cumacea, Foraminifera, Gastropoda, Harpacticoida, Insecta, Nematoda, Oligochaeta, Ostracoda, dan Polychaeta. Polychaeta merupakan taxa yang paling dominan bagi kedua-dua meio-makrobentos. Taburan meio-makrobentos adalah tidak sekata. Sembilan taxa daripada sebelas taxa yang didapati dalam sedimen menjadi makanan utama ikan buntal. Meio-makrobentos didapati menjadi salah satu sumber makanan penting bagi ikan buntal di Batang Saribas. Hasil yang diperolehi dalam kajian ini boleh digunakan untuk program atau kajian pemuliharaan ikan buntal di Batang Saribas pada masa hadapan.

Kata kunci: Ekologi, populasi dinamik, meio-makrobentos, Batang Saribas.

1.0 INTRODUCTION

1.1 Background

The term ecology can be simplified as the study of the structure and function of nature or the pattern of interaction between organisms and environment (Odum, 1975). Therefore, the ecological questions on meio-macrobenthos studies basically focus on ecophysiology and behavior of meio-macrobenthos, adaptation to various environmental parameters (temperature, salinity, anoxia and so on), recolonization of meio-macrobenthos, pollution effects on meio-macrobenthos and meio-macrobenthos as food for higher trophy levels (especially fishes).

Analyzation of community structure using a measurement of species diversity is a common ecological approach. Hypothesis testing whether in the laboratory or in the field is also an important means of research in ecological studies. Meio-macrobenthos researches aware that meio-macrobenthos assemblages could be experimentally manipulated (Coull and Gieve, 1988). Meanwhile, population dynamic refers to the study of constancy and change in population size (Ehrlich and Roughgarden, 1987). There was significant interest in population dynamics seeking to define controlling factors.

1.2 What are Meio-macrobenthos?

It's essential to know the meaning of benthos before look at the term meio-macrobenthos or meio-macrofauna. The term meio-macrobenthic also commonly used to refer this meio-macrobenthos group. Benthos refers to benthic community (both plant and animal) that live on or in or attached to the bottom of sediments (Kennish, 1990). Benthic fauna have been generally

differentiated into epifauna, a populations that residing on the seafloor or on the dense substrate and infauna, a populations living in the sediment (Kennish, 1990; Buchanan, 1984).

Generally, benthic fauna was grouped into three main categories according to their size. They are macrofauna (macrobenthos), meiofauna (meiobenthos) and microfauna (Kennish, 1990). According to Pechenik (2000), meio-macrobenthos defined as a community of small animals living in association with sediment. Basically, the group of meiobenthos and macrobenthos discriminated based on their sizes.

The term meiobenthos is derived from the Greek word meio meaning 'smaller' (Higgins and Thiel, 1988). They are the intermediate-sized organisms (between 42µm and 1mm) which inhabit the interstitial space between particles of sediments (Aryuthaka, 1991). Most of the studies on quantitative assessment defined meiobenthos as a group of organisms metazoans that retained on a sieve mesh size between 42µm to 500µm or 42µm to 1000µm (Higgins and Thiel, 1988) (Figure 1). Therefore, meiobenthos can be classified as tiny organisms that can be perceive with a basic microscope (preferably at least 40X magnification) but not with the naked eye.

In the other hand, macrobenthos are relatively large organisms that live on the surface or in the sediment at the bottom of lake, river and sea. They are organisms that retained by sieve with mesh size 500µm and visible to the unaided eyes. Basically, they are invisible in undisturbed bottom sediment (Buchanan, 1984). Hence, mudflats or subtidal estuarine bottom sediment may cover a variety of macrobenthic communities of various size and taxonomic groups. These benthic or bottom-dwelling animals either live in burrows or move freely on the

sediment. The species obtain their nutrition by deposit-feeding, filtration or can be predators, which feed on other bottom-dwelling animals.

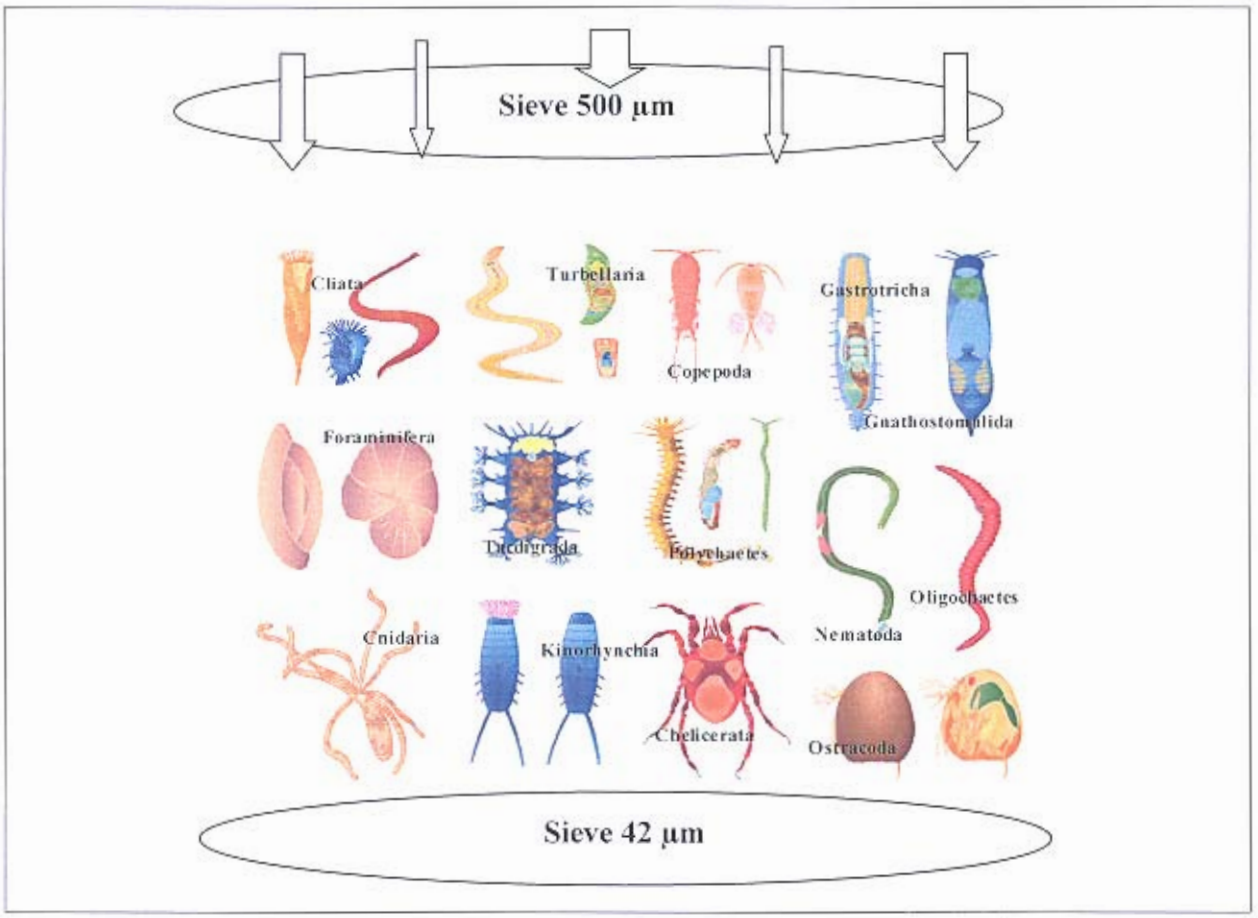

Figure 1: Marine meiobenthos retained on 42µm sieve.

1.3 Habitat and Abundance of Meio-macrobenthos

The distribution of both meiobenthos and macrobenthos is very wide. They inhabit both marine and freshwater habitat; from high on the beach to the deepest depths of the water body. They also occupy all types of sediment, from softest of mud to the coarsest shell gravels. Besides

that, they can be found at several 'above sediment' habitats like rooted vegetation, macro algae fronds, sea ice and some symbion meiobenthos living commensally in animal tubes, with bivalves, in association with wood bores or hydrozoans colonies (Coull, 1988).

Sediment grain size persuades the abundance and composition of meiobenthos. Different assemblages occur in different habitat. However, generally in most shallow areas (<100m) there are about 10^6 meiobenthos organisms per square meters of sea bottom (Coull, 1988). Vertical distributions of meiobenthos are restricted by the depth of the redox potential discontinuity (RPD) level like the margins of aerobic and anaerobic sediment.

According to Coull (1988), at least twenty-two of the 33 metazoan phyla consists meiobenthos taxa. Meiobenthos are either temporary or permanent (Kennish, 1990). While, the permanent meiobenthos are incorporating adults that adequately small size to be classified into this group, the temporary meiobenthos are typically larvae or juvenile stages of macrobenthos which become a part of the meiobenthos only during their juvenile stages. Yet, almost all major metazoan taxa are truly meiobenthos all over their life cycle (permanent meiobenthos).

The most important groups of meiobenthos are nematodes, copepods, ostracods, archiannelids, polychaete, oligochaete, tubellarians and ciliates. The other groups such as gastrotrichs, rotifers, tardigrades, kinorhynchs and gnathostomulids are less common but taxonomically interesting groups (Coull, 1988). In the other hand, the most important groups of soft-bottom macrobenthos are crustaceans (amphipods, isopods), bristle worms (polychaetes) and clams (bivalves).

1.4 Abiotic and Biotic Factors that Affect the Presence, Absence, Distribution and Composition of Meio-macrobenthos.

The distribution of meio-macrobenthos is influenced by abiotic and biotic factors (Giere *et al.*, 1988; Greiser and Faubel, 1988). The environmental characteristics namely physico-chemical parameters and sediment are the main factors influencing the presence, absence, distribution and composition of meiobenthos. These abiotic factors are such as particle sizes, salinity, dissolved oxygen, temperature, pH sediment, redox potential (Eh) and the depth from water surface to seabed. Particle size or grain size vital in determining the amount of interstitial space available for habitations and also one of the main factors since it reflects other physiographic parameters as well as the assessment is easy and economical (Giere *et al.*, 1988).

Temperature has significant probable for the determination of the distribution and abundance of meio-macrobenthos (Nybakken, 1993). Benthos populations alter their position to present temperature levels. The changes of temperature range are obvious in the intertidal zone and the uppermost layers of the beach. Thus, species that occupying sediment below one centimeter tends to have lower thermal tolerance than the surface-dwelling forms (Kennish, 1990). Temperature changes are minimal in the subtidal zone and intertidal sediments below 10-15cm depths. The maximum temperature that the meio-macrobenthos can tolerate in nature water is range from 45 to 50 ^{0}C (Carter *et al.*, 1982).

Particle size is importance because it controls the interstitial space as well as the ability of the sediment to retain and circulate water (Nybakken, 1993; Kennish, 1990). Smaller

meiobenthos inhibit the fine sediment which poor in volume of interstitial space contain and vise versa. Besides that, diversity of meiobenthos is higher in the sandy area than muddy area. This is due to the faster water movement through the pore spaces in the sandy sediment than the mud flat which responsible for renewing the oxygen supply (Nybakken, 1993). Only species that able to tolerate dominated the muddy area with fine particle size which created anaerobic sediment layers.

As stated, oxygen is an important factor in this environment. In many researches on meiobenthos, the majority fauna founded inhabit the upper 2 cm of sediment layer which is an oxygenated layer (Coull, 1988). The thickness of the oxygenated layer in the sediments influences by certain factors such as particle size, amount of organic materials, water turbulence and bacterial metabolism.

According to Kennish (1990), redox potential discontinuity (RPD) layer is a transition zone occurs between the upper aerobic layer (well oxidized, surface sediment layer) and the lower anaerobic layer (an anoxic sulfide layer). This zone is characterized by a rapid change from a positive redox potential (Eh) to a negative redox potential (Nybakken, 1993). These changes can be measured by using an electrode. The RPD layer is usually characterized by a gray color of the sediments. While, the oxidized layer above is usually brown or yellow in color and the anaerobic layer is black.

In response, meio-macrobenthos populations assemble near to the top few centimeters of the near-surface layer, gradually decreasing with increasing depth to the redox potential

discontinuity (RPD) layer. In several cases, more than 90% of the meiobenthos count peak in the upper 1cm of estuarine bottom sediments. In excess of 95% of meiobenthos in subtidal regime inhibit the top 7cm of sediments and 60 to 70% of the fauna, at the upper 2cm of sediments (Kennish, 1990).

Although the number of meiobenthos closer to zero in the redox (RPD) layer, some taxa may live below the RPD layer as true anaerobe organisms. Thus, meiobenthos are often restricted to the upper few mm or cm of oxidized sediment in muds and sediment that rich in detritus (Coull and Bell, 1988). While, in sands the meiobenthos can be found to the depth 50 cm (McLachlan, 1978).

Furthermore, interstitial salinity particularly the salinity of water between the mud particles influences meiobenthos distribution (McLusky, 1989). The low salinity limits the distribution of animals of both marine and fresh-water origin. Reduced of salinity often occur during low tide as a result of freshwater runoff and heavy rainfall. However the salinity changes usually confined on the uppermost layers of sediment. Salinity gradients vary greatly in estuaries. In large system, they change more gradually than in small, tidally mixed estuaries, but a seasonal freshwater pulse can have a marked input on the larger bodies of water (Boaden and Seed, 1985).

Giller and Malmquist (1998), stated that the pH value do influence the distribution of the meio-macrobenthos. The abundance of meio-macrobenthos is peak at high pH value. This is because this organism cannot tolerate with acidic condition. These also associate with high food availability in less acidic area. The pH value for sea water in tropical area range from 7.5 to 8.4

(Nybakken, 1993), pH for estuary is 5.0 to 6.5 (McLusky, 1989) and for fresh water the pH value normally more than 7 (Pennak, 1989; Giller and Malmquist, 1998).

In addition to the abiotic factors, biotic factors also influenced the abundance and distribution of meio-macrobenthos. These factors can be divided mainly into three categories (McLusky, 1989). First, the richness of the food supply in the form of detritus (all types of biogenic material like the fragments of dead plants, animals and other remains) which attract meiobenthos can create patchy distribution (Kennish, 1990). Secondly, the supply of larvae where the planktonic larvae carried out by the flushing current and finally the interactions include competition and predation effects.

1.5 Importance of Meio-macrobenthos

The importance and value of meio-macrobenthos cannot be underestimated. These benthic organisms play an important role in the aquatic ecosystem because of their significance in food webs. A food web is effectively a matrix of food chains showing the patterns of energy and materials flow through a community. Meio-macrobenthos are fulfilling a significant portion of the dietary needs for fishes especially juvenile fish like *Leiostomus xanthurus* (Smith and Coull, 1987), shrimp larvae and other organisms. Despite small size, meiobenthos have a high productivity (due to higher metabolic activity and high turnover rate) than that of macrobenthos and may contribute substantially to the production of benthos (Nybakken, 1993).

Generally, meiobenthos is a primary detritus feeder, its feed on diatoms, bacteria, protozoans and dissolved organic matter (Kennish, 1990). Besides meiobenthos serve as food for higher trophic levels, they are important in making detritus available for macroconsumer. Meio-macrobenthos are essential in mineralization of nutrient and as primary consumers of bacteria and algae. For example, the nematodes have nascent commercial value as potential food sources in aquaculture of some edible animals like penaeid shrimp and certain fish (Pechenik, 2000).

These criteria make them essential to the fishery industry because of the potential demise of those fishing resources dependent on benthos. Macrobenthos species like bivalves and gastropods from the phylum Mollusca have high commercial value especially in state of Sabah (Ridzwan, 1993 and Shabdin *et al.*, 1998). According to the Sarawak Fishery Department (1999), Sarawak has yielded 5.27 metric tan shellfish which contribute almost 22 million for economy of this state.

The meio-macrobenthos communities were used as bioindicator (pollution indicator species) in biomonitoring (Hynes, 1960; Perkins, 1974; Hellawell, 1986; Bilyard, 1987; Moore *et al.*, 1987; Mohd Long, 1987; Shabdin *et al.*, 2001). The sensitivity of meiobenthos to the environmental disturbance makes them competent as a good bioassay of community health and rather indicators of environmental changes (Coull, 1988). They can be used to test effluents and pollutant in water quality assessment.

For example, the Nematodes/ Copepods (N/C) ratio can be used to monitor the environmental changes. Nematodes are relatively insensitive to pollution impact (Moore and Bett, 1989). In the other hand, copepods are more sensitive to pollution. Besides that, macrobenthos play main role in bioaccumulation and transfer of contaminants to higher trophic levels in aquatic as well as terrestrial food chains (Larsson, 1984; Ciborowski & Corkum, 1988; Amyot, *et al.*, 1994; Pinel-Alloul, *et al.*, 1996). Generally, in a polluted environment, these meio-macrobenthos species would be replaced by species which is more tolerant of pollution.

1.6 Objectives

The objectives of this study are: 1) To survey the number of existing meio-macrobenthos taxa in Batang Saribas, 2) To determine the community structure (composition, distribution, density and diversity) of meio-macrobenthos in Batang Saribas, 3) To identify the environmental factors that influence the meio-macrobenthos community in Batang Saribas, and 4) To compare the density of meio-macrobenthos in the sediment with the gut content of puffer fish (fish diet).

2.0 MATERIALS AND METHODS

2.1 Study sites

This research has been carried out at Batang Saribas, which consists of overall 21,000 km^2 area and one of the main rivers in Sarawak. Kampung Manggut, where the congregation of puffer fish occurs, is situated in the area of Batang Saribas basin in Betong district of Sarawak, at latitude 01° 30.317'N and longitude 111° 20.874'E (Figure 2).

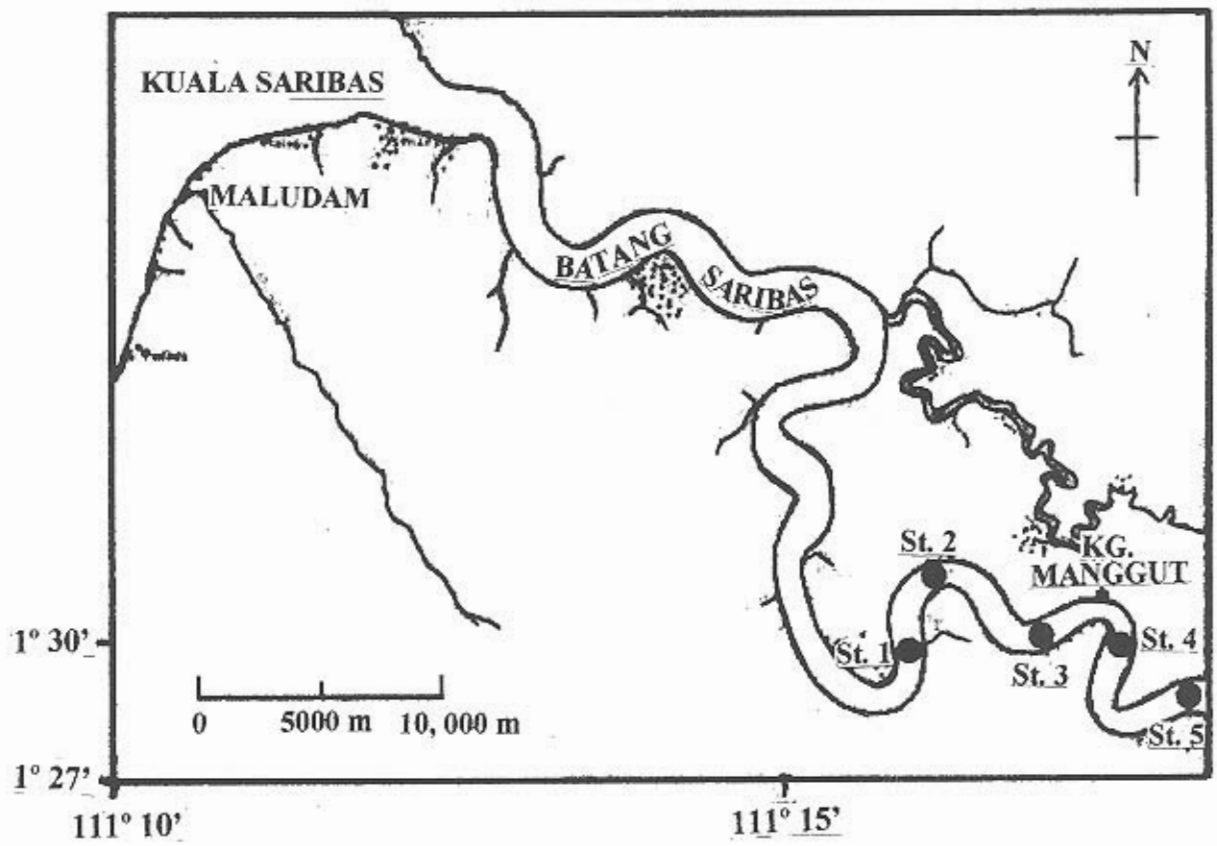

Figure 2: Map of study area (Batang Saribas with the sampling station).

The common vegetation found along the sampling station was palm (*Nypa fruticans*). Type of vegetation play significant role in providing food or materials for organic matter (Giller and Malmquist, 1998). The water of river was milky colored might due to the siltation. Some pictures of sampling station were attached in enclosure. Besides that, the mudflats are common habitats found in this study area. Five sampling stations fixed along the Batang Saribas. Stations were determined by using Global positioning system (GPS), model *Garmin GPS 12 CX*. The locations of stations according to GPS are shown in Table 1.

Table 1: Locations of Station

Station	Name of station	GPS
St. 1	Kampung Supah	01° 30.654' N, 111° 18.126' E
St. 2	Tanjung Keranji	01° 31.296' N, 111° 18.839' E
St. 3	Kampung Manggut	01° 30.317' N, 111° 20.874' E
St. 4	Kampung Baring	01° 30.315' N, 111° 22.568' E
St. 5	Kampung Serambang	01° 28.817' N, 111° 23.643' E

2.2 Sampling Technique

A fishing boat employed for the purpose of sampling. All samples were collected during high tides. This sampling was done in August 2003. Nowadays, remote samplers can be used for sampling in sublittoral area which can be done from the boat. For this study, sediment samples for meiobenthos studies were taken using simple flow through corer (*Rigosha/Japan*) with 3.5 cm internal diameter.

Seven replications (corer sample) were taken where three used for meiobenthos identification, two for chlorophyll *a* analysis and one each for total organic matter analysis and grain size analysis. The three replicates of the meiobenthos samples were taken to reduce the variability of the sampling error. For the macrobenthos studies, sediment samples were taken by using grab sampler (*Kahlsico/USA*) with an area of 0.11 m^2. Sediment samples for meio-macrobenthos analysis preserved were in 5 % formalin.

2.3 Physico-chemical Parameters

Water parameters such as dissolved oxygen (DO), pH, and temperature (at surface, middle and bottom of water); conductivity, turbidity and salinity was taken *in-situ* at each station. The pH meter (*Jenvey 30TI*) and refrectormeter (*Atago S-Z8*) were used. *Cyberscan DO 300 Series* was used for temperature and DO measurements. Seechi Disk was used to measure the transparent of the water. Data on these physico-chemical parameters was collected from Magdelyn, 2004.

2.4 Laboratory Analysis

2.4.1 Meiobenthos Extraction

In laboratory, preserved sediment samples (meiobenthos) were sieved with 500 µm and 45 µm sieves mesh. The residues that remained on 45 µm sieve-mesh are considered as meiobenthos. They were transferred into labeled bottles and preserved in 5 % formalin. Rose Bengal (1%) added as a vital stain to the meio-macrobenthos to facilitate counting job as well as aids in separating organisms from sediments and detritus.

Meiobenthos specimens in the residue sorted using an Irwin loop (Westheide and Purschke, 1988). Meiobenthos counted in grid Petri dish (where each grid represents 1 cm^2) under a stereo-microscope. Compound microscope was also used in the identification process. The meiobenthos were identified to higher taxa level due to the determination of these organisms to species level may require a long period of time. Identification done based on the morphology characteristics of each organism and the number of individuals was counted. Then the data of each station was converted to density in units of individuals/ 10 m^2.

2.4.2 Macrobenthos Extraction

The macrobenthos extraction process is quite similar as meiobenthos extraction. The preserved sediment samples were sieved with 500 μm and the residues that remained on sieve are considered as macrobenthos. They were transferred into labeled bottles and preserved in 5 % formalin and rose Bengal (1%) added. Then, the sediment sample was poured into a tray (white in color) for sorting process.

Since the macrobenthos are able to be seen with naked eyes, the organisms that stained with rose Bengal were sorted easily. Sorted macrobenthos for each station were identified to higher taxa level under a stereo-microscope based on the morphology characteristics of each organism and the number of individuals is counted. Then the data of each station was converted to density in units of individuals/ m^2.

2.4.3 Analysis of Chlorophyll *a*

Lorenzen and Jerry, in Greiser and Faubel (1988) agreed that spectrophotometric method performs conventional for the detection of chlorophyll *a* in the sediment samples. A detailed description of the method with slight modification by Wasmund is used (Greiser and Faubel, 1988). Definite amount of sediment sample (1 cm of top layer of the sediment core) placed into a mortar homogenize by grinding. Then, 5 to 10 ml acetone was added to obtain 90% concentration and homogenized again. It was then cooled with ice to decrease evaporation of acetone.

The suspension were transferred into centrifuge tube and centrifuged at 4000g for 30 minutes. Supernatant decanted into a cuvet and extinction measured at 664nm, 647nm and 630nm using the Ultra-violet-Spectrophotometer (SECOMAM - PRIM Light and Advanced). In acidification methods, 50µl of 0.2M hydrochloric acid (HCl) were added to 1.5ml of extract volume and absorbance at 665nm was determined before and after acidification. Turbidity blank was measured at 750nm. All values from 665, 664, 647 and 630 were subtracted to the blank value before calculating the pigment content. The value for the chlorophyll *a* calculated using the formula below:

$$\text{Chlorophyll } a \text{ (mg/m}^3) = \frac{26.7 (E_0 - E_a) \times V}{Vs \times L}$$

Where, E_0 = absorbance before acidification at 665nm
E_a = absorbance after acidification at 665nm
V = Volume of water content of the samples plus acetone added
Vs = Volume of sediment sample
L = Path length (cm) of the spectrophotometer cell.

2.4.4 Grains Size Analysis

The Wentworth scale was used as a guideline where the dry sieved and pipette analysis employed for this analysis. First of all, sediment sample for each station sieved with a mesh size of 2 mm. Sieved sample then weighed for 10 grams. The weighed sample put into a flask cone and 100 ml of distilled water added. The mouth of the flask sealed with parafilm. The flask left on the shaker for 18 hours. After 18 hours, the sample sieved through a sieve with mesh size of 50 µm. The sample left on the sieve rinsed with distilled water until the water which comes out

from the sieve is clear. The sieved sample collected using a beaker and poured into a 1000 ml measuring cylinder (Soil Conservation Service, 1984).

Distilled water added in the cylinder until the 1000 ml level. Particles that retained on the sieve rinsed into a Petri dish. Earlier, all of the Petri dishes weighed and labeled appropriately according to friction. The Petri dish containing the first sample fraction is kept in an oven with the temperature of 105° C and left for overnight until dry. Then, the fraction is weighed. The initial weight is recorded.

For clay, coarse and fine silt fraction, sample pipeted using a 20 ml pipet on to Petri dishes which have been labeled according to the type of fraction. Petri dishes (containing the sample fraction) also dried in an oven at 105 °C for overnight. The initial weight for the Petri dishes recorded. The time fraction for coarse, silt and fine silt and clay is as follows:

Table 2: Timetable for the soil fraction analysis.

Sample	Sand	Coarse silt	Fine silt	Clay
Sample 1	0 min	4 min 1 sec	1 h 4 min 27 sec	4 h 30 min
Sample 2	2 min	7 min 1 sec	1 h 7 min 27 sec	4 h 33 min
Sample 3	8 min	13 min 1 sec	1 h 13 min 27 sec	4 h 39 min
Sample 4	14 min	19 min 1 sec	1 h 19 min 27 sec	4 h 45 min
Sample 5	20 min	25 min 1 sec	1 h 25 min 27 sec	4 h 51 min

Note: h = hour, min = minutes, sec = seconds

Particle sizes were calculated using the formula:

i) Clay (2 micron) (%) = $100 \times (RW_2 \times CF) / TW$

ii) Silt (5 micron) (%) = $[100 \times (RW_{20} \times CF) / TW]$ – Clay (%)

iii) Sand (63 micron) (%) = Net weight / TW × 100

iv) Coarse silt (20 micron) (%) = 100 – (Fine silt + clay + Sand) (%)

Where, RW_2 = Sample dry weight
CF = 1000 ml / DV
DV = Pipet volume
TW = Sample total weight
RW_{20} = Weight of dried residues <20 micron

2.4.5 Organic Matter Analysis

The present of total organic matter (TOM) in the sediment samples were determined by using the ash-free dry weight method. Unpreserved samples used in this test. The analytical method involves drying sediment samples at 60 °C for 24 hours and the dry weight value were determined. Combustion of the organic matter is done at high temperatures (475 °C) for 2 hours and the ash-free dry weight calculated from the loss of weight (Greiser and Faubel, 1988). The loss of weight indicates the amount of total organic matters in the samples.

2.5 Data Analysis

Three community statistics applied to measure species diversity, richness and evenness. The Shannon-Weaver's index (Shannon and Weaver, 1963; Kikkawa, 1986) used to calculate diversity indices,

$$H' = -\sum_{i=1}^{S} p_i \log_2 p_i$$

where, H'= diversity index
$p_i = ni/ N$
n_i = number of individuals of i^{th} species
N = total number of species.
s = number of spesies.

Species richness *d* (Margalef, 1958) and species evenness *J'* (Pielou, 1966) calculated using formula below:

$d = (s - 1) / (\ln N)$ where, *d* = species richness
N = total number of individuals

$J' = H' / \log_2 s$ where, H' = diversity
s = total number of species

The significant of null hypothesis H_o (there is significant difference in densities between stations) and H_a (there is no significant difference in densities between stations) were analyzed. ANOVA one way used to determine the correlation between meiobenthos and physico-chemical parameters with the help of SPSS (Statistical Package for Social Sciences) software.

3.0 RESULTS

3.1 Physico-chemical Parameters

The physico-chemical parameters for each sampling stations are shown in Table 3. These measurements were taken during high tides. Generally, there are no great differences in certain parameters like temperature, pH and dissolved oxygen (DO) from one station to another. The range for temperature is from 29°C to 32°C, pH from 7.2 to 7.6 and DO from 5 to 7 mg/L respectively. The maximum salinity value recorded was 18 psu for St.1 and St. 4; while, the minimum salinity value was 10 psu at St. 5. Therefore, the salinity varies greatly (8 psu). Water transparent at St. 1 was 50.2 cm, shows that the station more clear than others. The lower

transparent value was 26.7 cm in St. 5. The great different of transparent value in study area was 23.5 cm.

Besides that, biological components such as Total Organic Matter (TOM) and Chlorophyll *a* were also measured for each sampling station. The TOM for study area found to be range from 0.02 to 0.30 gram/ gram. St. 5 contains high composition of TOM (almost 0.28 gram) compare to other stations which range from 0.02 to 0.08 gram. The TOM composition was lower in St. 3. Chlorophyll *a* composition was higher (1.236 mg/m^3) in St. 2 and lower in St. 5 (0.076 mg/m^3).

Table 3: Physico-chemical parameters and biological component at each station

Physico-chemical and Biological Parameters	Station				
	St. 1	St. 2	St. 3	St. 4	St. 5
Temperature (° C)	31.9	29.8	30.3	29.0	30.7
pH	7.33	7.55	7.29	7.33	7.24
Salinity (psu)	18	17	12	18	10
Transparency (cm)	50.2	27.3	38.8	26.9	26.7
DO (mg/L)	5.86	6.52	7.02	6.61	6.78
TOM (g/g)	0.0812	0.0436	0.0216	0.0634	0.2790
Chlorophyll *a* (mg/m^3)	1.053	1.236	0.427	0.458	0.076

psu = practical salinity unit.

A particle fraction for study area was given in Figure 3. Sand refers to sediment particles with size bigger than 50μm while the silt and clay is the particles size smaller than 50μm. Sand fraction for each station is 32.4 % (St. 1), 83.7 % (St. 2), 80.5 % (St. 3), 89.9 % (St. 4) and 40.5 % (St. 5) correspondingly. Thus, it can be simplified that St. 2, 3 and 4 contain high sand fraction (more than 80 %) and the St. 1 and St. 5 contain low sand fraction. The percentage of silt and

clay fraction for each station is 67.6 % (St. 1), 16.3 % (St. 2), 19.5 % (St. 3), 10.1 % (St. 4) and 59.5 % (St. 5) respectively. This shows that the St. 1 and St. 5 have high percentage of silt and clay fraction as compared to other three stations.

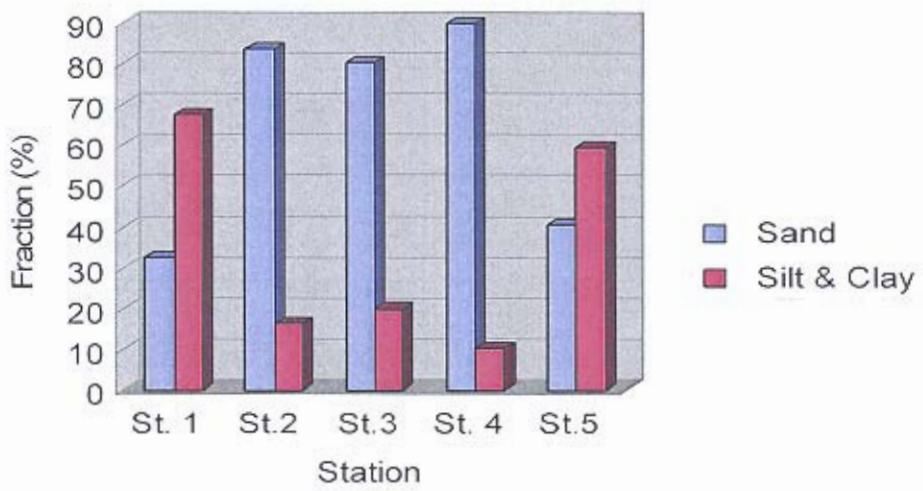

Figure 3: Particle fraction at each station

3.2 Meio-macrobenthos Compositions

Eleven taxa were identified in study area; eight taxa of meiobenthos and macrobenthos respectively. They comprise of nematode, polychaete, oligochaete, harpacticoid, ostracod, bivalve, foraminiferan, amphipod, insects, cumacean and gastropod.

3.2.1 Meiobenthos

Eight taxa of meiobenthos that were identified in study area are nematodes, polychaete, oligochaete, harpacticoid, ostracod, bivalves, insects and foraminiferan (Table 4). The dominant taxon at St. 1 was Polychaeta with average density of 29.47 ind/ 10 cm^2. Yet again, the Nematoda